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Seven dark fruiting lichens of *Caloplaca* from China

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Abstract —Detailed taxonomic descriptions with photos are presented for seven dark fruiting *Caloplaca* species found in China. *Caloplaca albovariegata*, *C. atrosanguinea*, and *C. diphyodes* are apparently new to Asia, *C. bogilana*, and *C. variabilis* are new to China, and *C. conversa* and *C. pulicarioides* are new to northern China.

Key words —*Ascomycota*, *Teloschistales, Teloschistaceae*

Introduction

The large cosmopolitan genus *Caloplaca* (*Teloschistaceae*, *Teloschistales*, *Lecanoromycetes*, *Ascomycota*) was established by Theodor Fries in 1860 (Kirk et al. 2008). *Caloplaca* is characterized by a totally immersed to subfruticose crustose thallus, typically teloschistacean ascus, polarilocular ascospores, and various anthraquinones or no substances (Poelt & Pelleter 1984, Søchting & Olecha 1995). The genus reportedly comprises more than 500 species worldwide (Kirk et al. 2008), but only 59 species are known in China (Abbas et al. 1996, Aptroot & Seaward 1999, Arocena et al. 2003, Wei 1991, Xahidin et al. 2010, Zhao & Sun 2002).

During our study of *Lecanora* Ach. in China, six *Caloplaca* species with black apothecial discs and one with a red-brown apothecial disc were found. Of these, five species are new to China. Descriptions with photos of important characters of these species are provided here.

Materials & methods

The specimens studied are preserved in SDNU (Lichen Section of Botanical Herbarium, Shandong Normal University). Morphological and anatomical characters

were examined under a COIC XTL7045B2 stereomicroscope and Olympus CX41 polarizing microscope. Lichen substances were identified using the standardized thin layer chromatography techniques (TLC) with solvent system C (Orange et al. 2010). Photos were taken under Olympus SZX16 and BX61 with DP72.

Terms applied to *Caloplaca* apothecial structures of are shown below in Fig. 1.

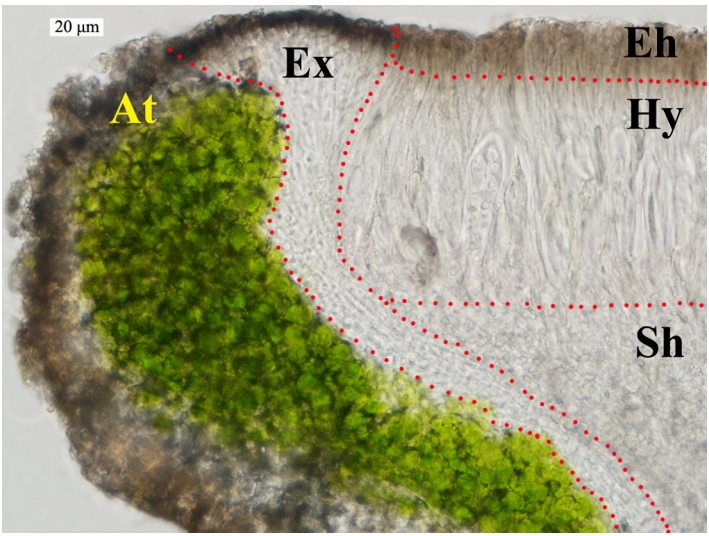

Figure 1. Terms applied to apothecial structures in *Caloplaca:* At = amphithecium; Ex = inner exciple; Eh = epihymenium; Hy = hymenium; Sh = subhymenium. Bar = 20µm.

Taxonomic descriptions

Caloplaca albovariegata (B. de Lesd.) Wetmore, Mycologia 86: 816 (1995 ["1994"]) Figs 2, 3

Morphology — Thallus saxicolous, crustose, greenish gray to blackish gray, stipitate areolate); cortex with crystals in some places; medulla with obvious crystals; algal layer clustered; prothallus not seen. Apothecia lecanorine, sessile; disc black, epruinose; inner exciple black at the top; amphithecium with very thick algal layer and obvious crystals; epihymenium brown, without crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 15–20 × 7.5–10 µm, isthmus 2–4.5 µm; paraphyses simple, with 1–2 somewhat swollen apical cells. Pycnidia not observed.

Chemistry — Epihymenium K+ light purple, C–; amphithecial cortex and top of inner exciple K+ purple, C+ purple. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: no lichen substances detected by TLC.

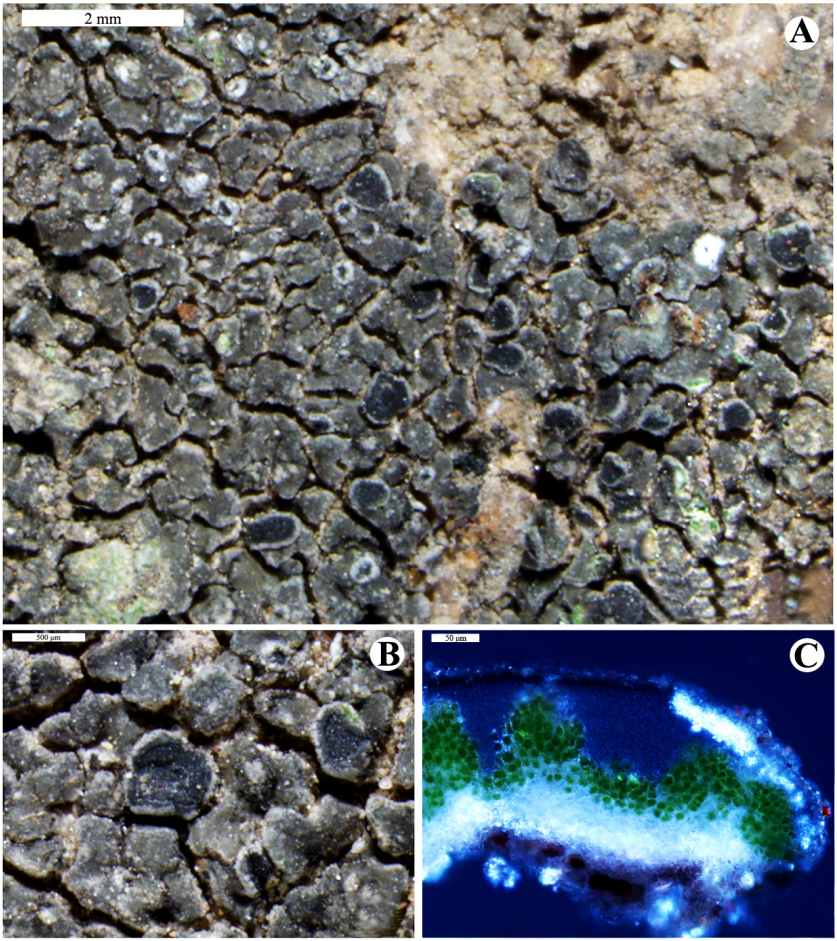

Figure 2. *Caloplaca albovariegata* (Wang 20124075, SDNU). A: Thallus; B: Apothecium; C: Thallus section showing clustered algal layer and crystals in cortex and medulla. Scale bars: A = 2 mm; B = 500 µm; C = 50 µm.

Distribution — *Caloplaca albovariegata* has been reported from western North America (Wetmore 1995, 2007). New to China and Asia.

Specimen examined: **China**. **Shanxi**, Ningwu county, Mt. Luya, alt. 2500 m, on rock, 26 Aug. 2011, H.Y. Wang 20124075 (SDNU).

Comments — *Caloplaca peliophylla* resembles *C. albovariegata* in the stipitate areolate thallus but differs in the shiny olive brown thallus and lighter brown apothecial discs. The similar *C. atroalba, C. diphyodes, C. ursina,* and *C. variabilis*

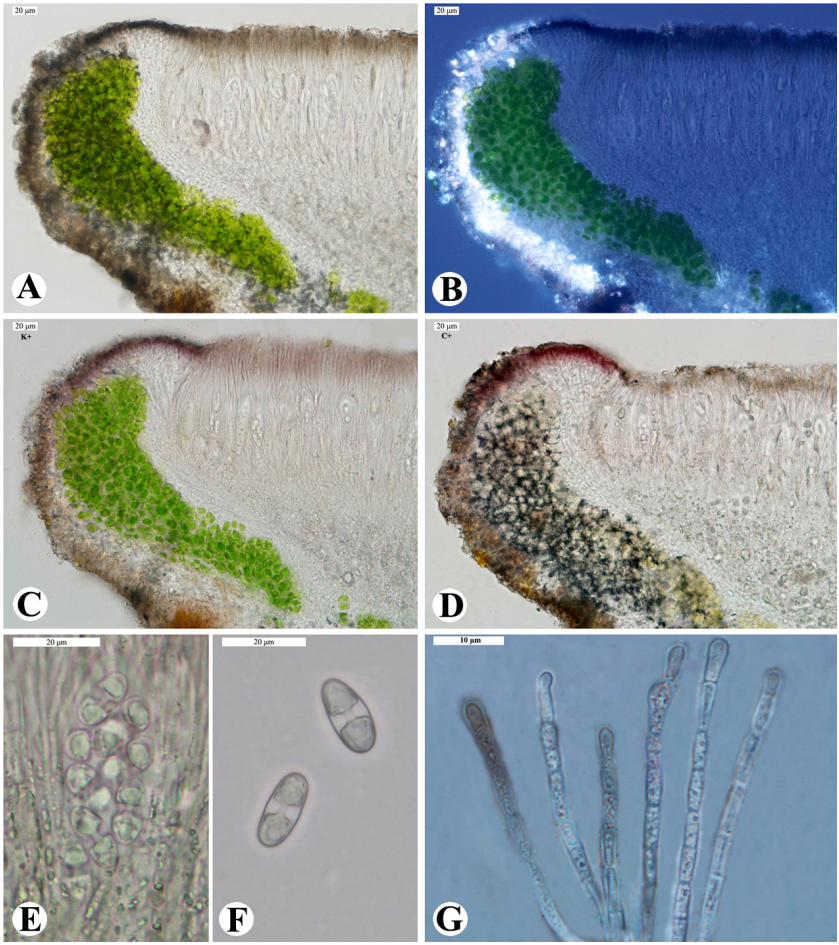

Figure 3. *Caloplaca albovariegata* (Wang 20124075, SDNU). A: Apothecium section; B: Amphithecium with obvious crystals; C: K+ reaction in epihymenium, amphithecial cortex, and top of inner exciple; D: C+ reaction in amphithecial cortex and top of inner exciple; E: 8-spored ascus; F: Polarilocular ascospores; G: Simple paraphyses with 1–2 somewhat swollen apices. Scale bars: A–F = 20 µm; G = 10 µm.

differ by having non-stipitate or only partly stipitate areolate thalli. See further discussion under *C. variabilis*.

Caloplaca atrosanguinea (G. Merr.) I.M. Lamb, Natl. Mus. Canada Bull. 132: 305 (1954) Figs 4, 5

Morphology — Thallus corticolous, crustose, light grey; cortex with indistinct crystals; medulla with obvious crystals; algal layer even; prothallus not

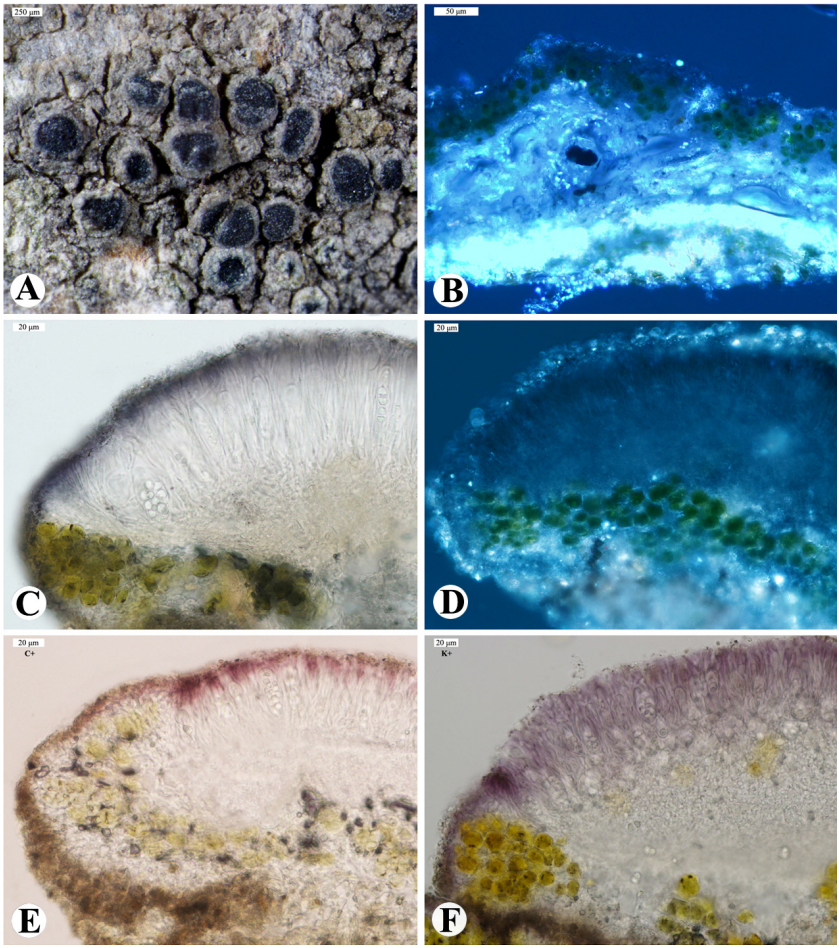

Figure 4. *Caloplaca atrosanguinea* (Zhao 20116843A, SDNU). A: Thallus; B: Even algal layer and crystals in cortex and medulla; C: Apothecium section; D: Crystals in amphithecium and epihymenium; E: C+ reaction in epihymenium and top of inner exciple; F: K+ reaction in epihymenium, amphithecial cortex, and top of inner exciple. Scale bars: A = 250 µm; B = 50 µm; C–F = 20 µm.

seen. Apothecia lecanorine, sessile; disc black or somewhat brown, epruinose; inner exciple black at the top; amphithecium with crystals; epihymenium dark black, with crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 10–12.5 × 6.2–7.5 µm, isthmus 2–3 µm; paraphyses simple to branched at the top, with 2–3 swollen apical cells. Pycnidia present, ostiole black; conidia bacilliform, 3.5–6.3 × 0.8–1 µm.

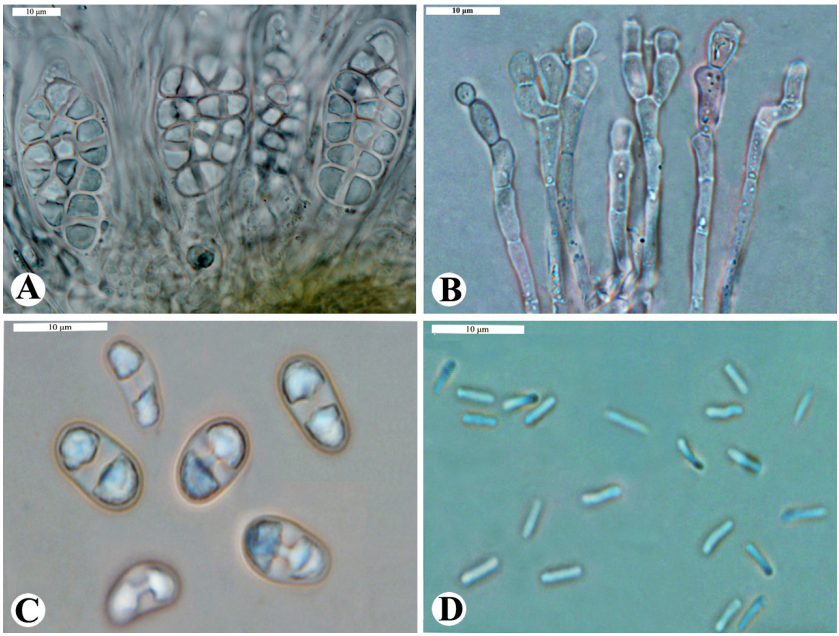

Figure 5. *Caloplaca atrosanguinea* (Zhao 20116843A, SDNU). A: 8-spored ascus; B: Simple to branched paraphyses with 2–3 swollen apical cells; C: Polarilocular ascospores; D: Bacilliform conidia. Scale bars = 10 µm.

Chemistry — Epihymenium K+ reddish then purple, C+ reddish purple (Fig. 4E); top of inner exciple K+ reddish then purple, C+ reddish purple; amphithecial cortex K+ light purple, C–. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: no lichen substances detected by TLC.

Distribution — *Caloplaca atrosanguinea* has been reported from North America (McCune 1984, Wetmore 1995, 2007). New to China and Asia.

Specimen examined: **China. Xinjiang**, Urumqi county, Nanshan-Bayi Forest farm, alt. 1775 m, on bark, 26 Jun. 2005, J.Z. Zhao 20116843A (SDNU).

Comments — *Caloplaca parvula* resembles *C. atrosanguinea* in corticolous habitat and dark colored epihymenium but is distinguished by K– epihymenium and tissues and ascospores with a very narrow (1–1.5 µm) isthmus (McCune 1984). *Caloplaca floridana* and *C. pollinii* resemble *C. atrosanguinea* in corticolous habitat and the K+ purple epihymenium. However, *C. floridana* has an epihymenium without crystals and ascospores with a wider isthmus (5.5–7 µm; Wetmore 1995), and *C. pollinii* has a patchily yellow-brown hymenium and four lichen substances (parietin, emodin, fallacinol, fallacinal).

Caloplaca bogilana Y. Joshi & Hur, The Lichenologist 42: 716 (2010) Figs 6, 7

Morphology — Thallus saxicolous, crustose, areolate, grayish-white, glossy, thick; cortex and medulla with obvious crystals; algal layer even; prothallus not seen. Apothecia lecanorine, sessile; disc brown to black, epruinose; top of inner exciple concolorous with disc; amphithecium with obvious crystals; epihymenium orange-brown, with concolorous crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 10–

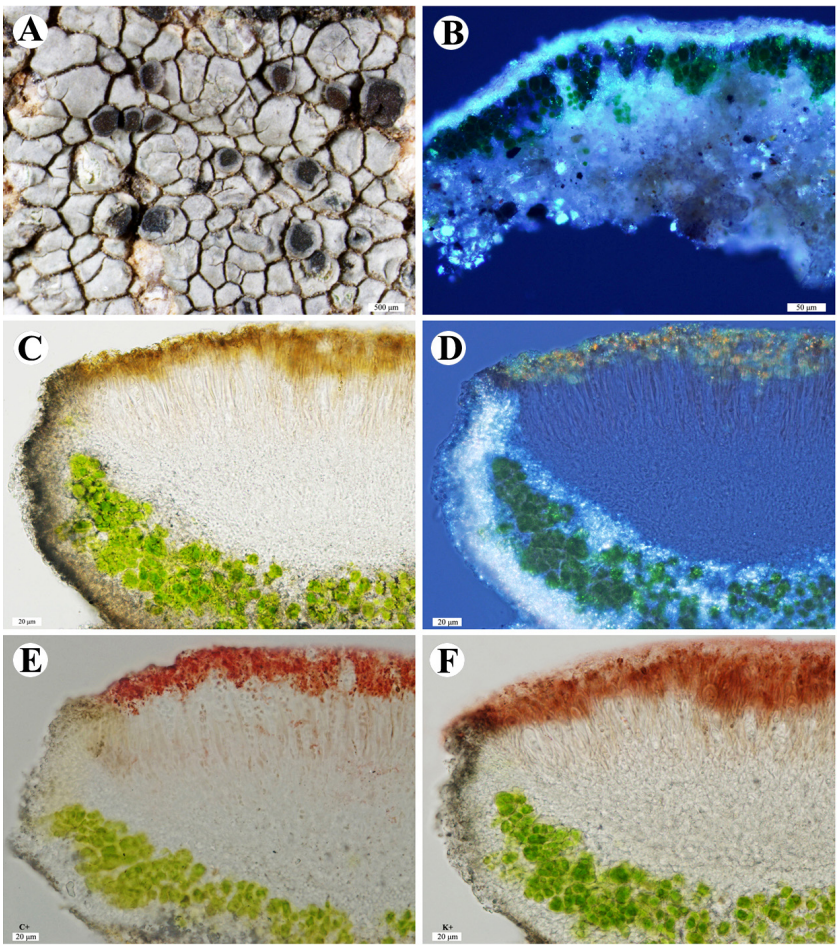

Figure 6. *Caloplaca bogilana* (Cheng 20120490B, SDNU). A: Thallus; B: Even algal layer and crystals in cortex and medulla; C: Apothecium section; D: Obvious crystals in amphithecium and orange-brown crystals in epihymenium; E: C+ reaction in epihymenium; F: K+ reaction in epihymenium. Scale bars: A = 500 µm; B = 50 µm; C–F =20 µm.

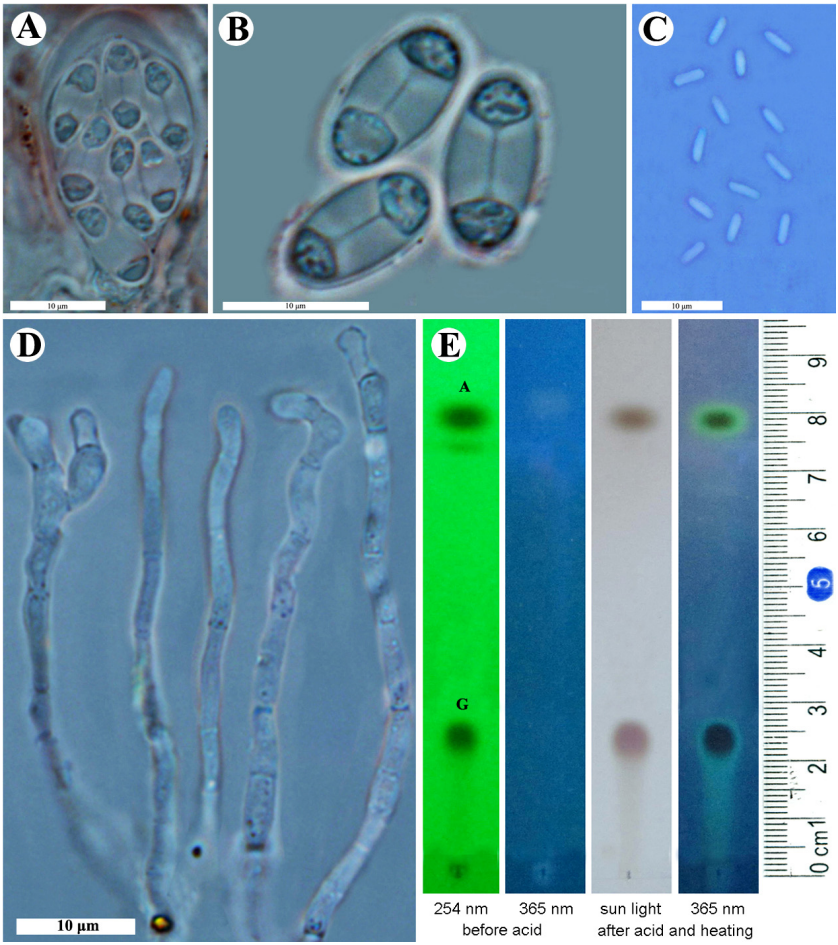

Figure 7 *Caloplaca bogilana* (Cheng 20120490B, SDNU). A: 8-spored ascus; B: Polarilocular ascospores; C: Long ellipsoid conidia; D: Simple to branched paraphyses; E: TLC result. Scale bars = 10 µm.

12.5 × 4.0–6.3 µm, isthmus 3.5–5.0 µm; paraphyses simple to branched at the top. Pycnidia numerous, ostiole black; conidia long ellipsoid, 3.0–4.5 × 1.1–1.6 µm.

Chemistry — Epihymenium K+ red, C+ red; amphithecium and top of inner exciple K–, C–. Thallus and medulla K+ yellow, C+ red, KC+ red, P–. Secondary metabolites: atranorin, gyrophoric and lecanoric acids, ± parietin.

Distribution — *Caloplaca bogilana* has been reported previously only from coastal areas of Bogil Island in South Korea (Joshi 2010), while we found it from both coastal and inland areas in China.

Specimens examined: **CHINA**. **Liaoning**, Beipiao city, Mt. Dahei, alt. 1300 m, on rock, 14 Aug. 2011, Y.L. Cheng 2012490B (SDNU), 20120489B (SDNU); **Shandong**, Yantai city, Mt. Kunyu, alt. 400 m, on rock, 12 Jun. 2010, Y.L. Cheng 20128005 (SDNU).

Comments — *Caloplaca subleptozona* resembles *C. bogilana* in having an areolate thallus and atranorin but differs in its biatorine apothecia with pruinose discs and UV+ thallus.

Caloplaca conversa (Kremp.) Jatta, Syll. Lich. Ital.: 254 (1900) Figs 8, 9

Morphology — Thallus saxicolous, crustose, ivory-white to grayish-white, areolate, pruinose; cortex and medulla with obvious crystals; algal layer even;

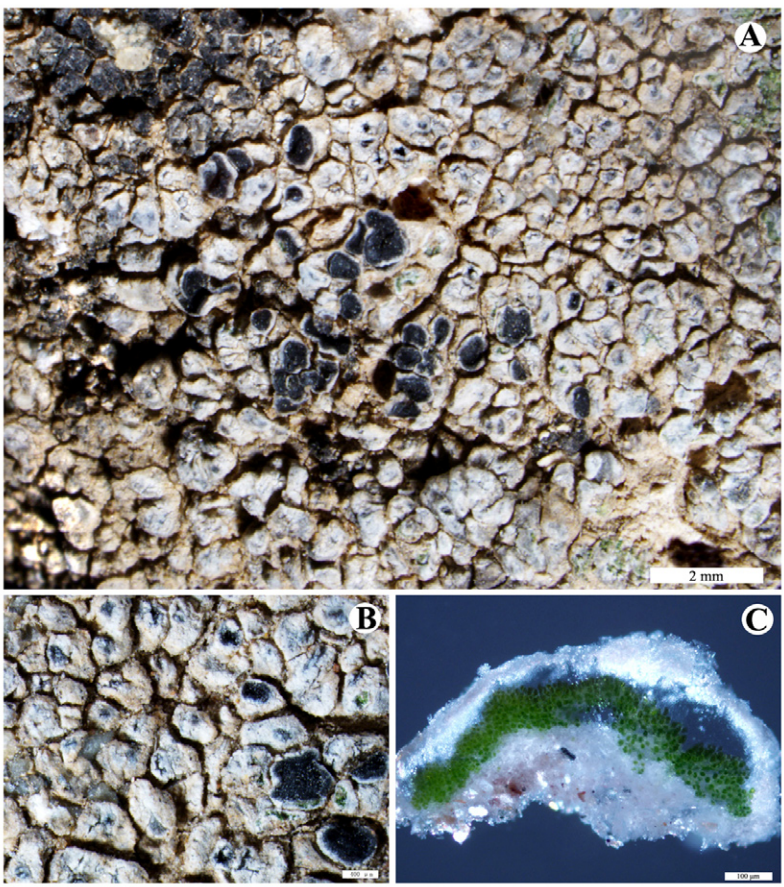

Figure8. *Caloplaca conversa* (Wang 20122965, SDNU). A: Thallus; B: Pruina and apothecia in thallus, showing; C: Even algal layer and crystals in cortex and medulla. Scale bars: A = 2 mm; B = 400 μm; C = 100μm.

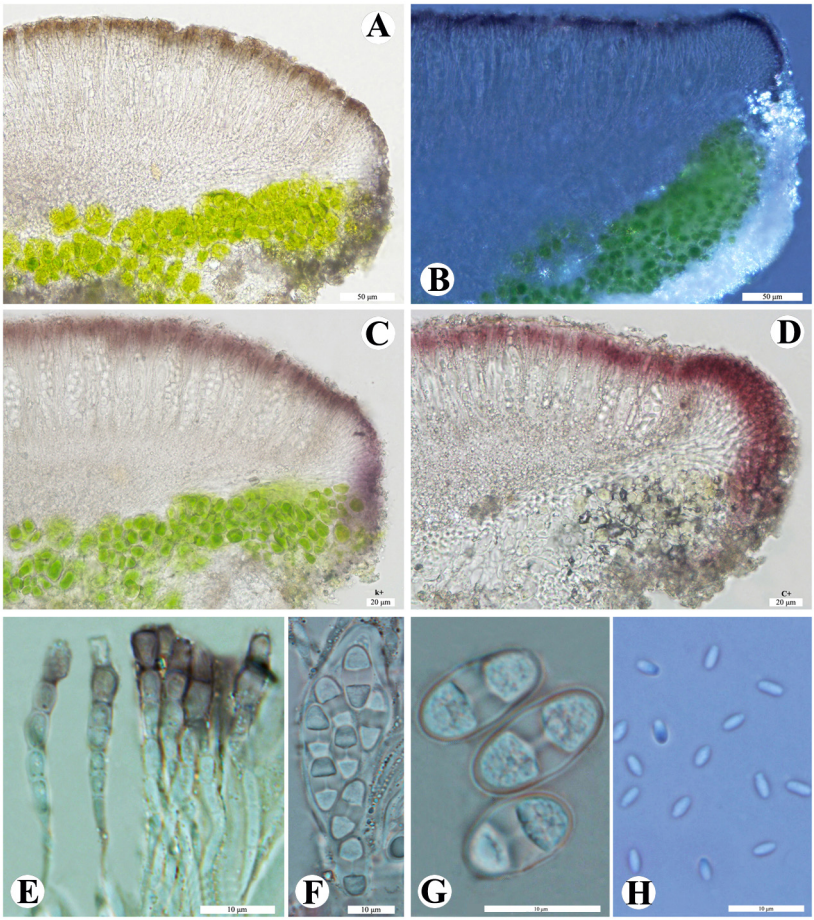

Figure 9. *Caloplaca conversa* (Wang 20122965, SDNU). A: Apothecium section; B: Crystals in amphithecium; C: K+ reaction in epihymenium, amphithecial cortex, and top of inner exciple; D: C+ reaction in epihymenium, amphithecial cortex, and top of inner exciple; E: Simple paraphyses with 4-–6 swollen apical cells; F: 8-spored ascus; G: Polarilocular ascospores; H: Pyriform conidia. Scale bars: A, B = 50 μm; C, D = 20 μm; E–H = 10 μm.

prothallus not seen. Apothecia lecanorine, immersed or adnate; disc black, epruinose; inner exciple black at the top; amphithecium with obvious crystals; epihymenium brown, without crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 10–15 × 4–6.5 μm, isthmus 2–4.5 μm (Figs 9F, G); paraphyses simple, with 4–6 swollen apical cells. Pycnidia present, ostiole black; conidia pyriform, 3–4 × 2–2.5 μm.

Chemistry — Epihymenium, top of inner exciple, and amphithecial cortex K+ weakly purple, C+ purple. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: no lichen substances detected by TLC.

Distribution — *Caloplaca conversa* has been reported from Europe, North America, and Hong Kong, China (Aptroot & Seaward 1999, Breuss 1988, Wetmore 1995, 2007). New to northern China.

Specimens examined: **CHINA**. **Inner Mongolia**, Ba Yan Hot, Mt. Helan, alt. 1500 m, on rock, 19 Aug. 2011, H.Y. Wang 20122965 (SDNU), 20122520 (SDNU); 19 Aug. 2011, P.M. Wang 20123717 (SDNU), 20123333 (SDNU); alt. 1800 m, on rock, 19 Aug. 2011, H.Y. Wang 20123141B (SDNU); alt. 2000 m, on rock, 19 Aug. 2011, D.B. Tong 20123046 (SDNU); Wulate Houqi, Mt. Helan, alt. 1600 m, on rock, 16 Aug. 2011, D.B. Tong 20123522 (SDNU), 20122837 (SDNU), 20122460 (SDNU), 20123568 (SDNU), 20123471 (SDNU); 17 Aug. 2011, P.M. Wang 20123635 (SDNU), 20123618 (SDNU), 20123902B (SDNU), 20123109 (SDNU); 17 Aug. 2011, X.R. Kou 20123673 (SDNU); alt. 1700 m, on rock, 17 Aug. 2011, X. R. Kou 20123898 (SDNU), 20123676 (SDNU); Wulate Houqi, Mt. Hebashige, alt. 1600 m, on rock, 16 Aug. 2011, H.Y. Wang 20123003 (SDNU), 20123017 (SDNU), 20122966 (SDNU), 20123977 (SDNU), 20123518A (SDNU).

Comments — *Caloplaca alociza* and *C. chalybaea* resemble *C. conversa* in black sunken apothecia. However, *C. alociza* has ± immersed thallus and larger ascospores (15–18 × 7–8 μm) (Wilk & Flakus 2006), while *C. chalybaea* has a black-brown to lead-grey thallus with conspicuous black prothallus and mature apothecia with blue pruina. The also similar *C. conciliascens* differs in having an indistinct thallus, lecideine apothecia with brownish red discs, and a blackish green top of inner exciple.

Caloplaca diphyodes (Nyl.) Jatta, Syll. Lich. Ital.: 259 (1900) Figs 10, 11

Morphology — Thallus saxicolous, crustose, off-white, areolate; cortex with somewhat crystals; medulla with obvious crystals; algal layer even; prothallus not seen. Apothecia lecanorine, sessile; disc black, epruinose; inner exciple black at the top; amphithecium with obvious crystals; epihymenium dark brown, without crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 12.5–15 × 6–8 μm, isthmus 3–4 μm; paraphyses simple, with 3–6 swollen apical cells. Pycnidia present, usually on marginal areoles, ostiole black, margin white; conidia filiform, 15–17.5× 0.6–0.7 μm.

Chemistry — Epihymenium, top of inner exciple, and amphithecial cortex K+ purple, C+ weakly purple. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: no lichen substances detected by TLC.

Distribution — *Caloplaca diphyodes* has been reported from Europe (Coste 2005, Magnusson 1937). New to China and Asia.

Specimens examined: **CHINA**. **Inner Mongolia**, Ba Yan Hot, Mt. Helan, alt. 1300m, on rock, 19 Aug. 2011, H.Y. Wang 20122508 (SDNU), 20122519 (SDNU), 20122615

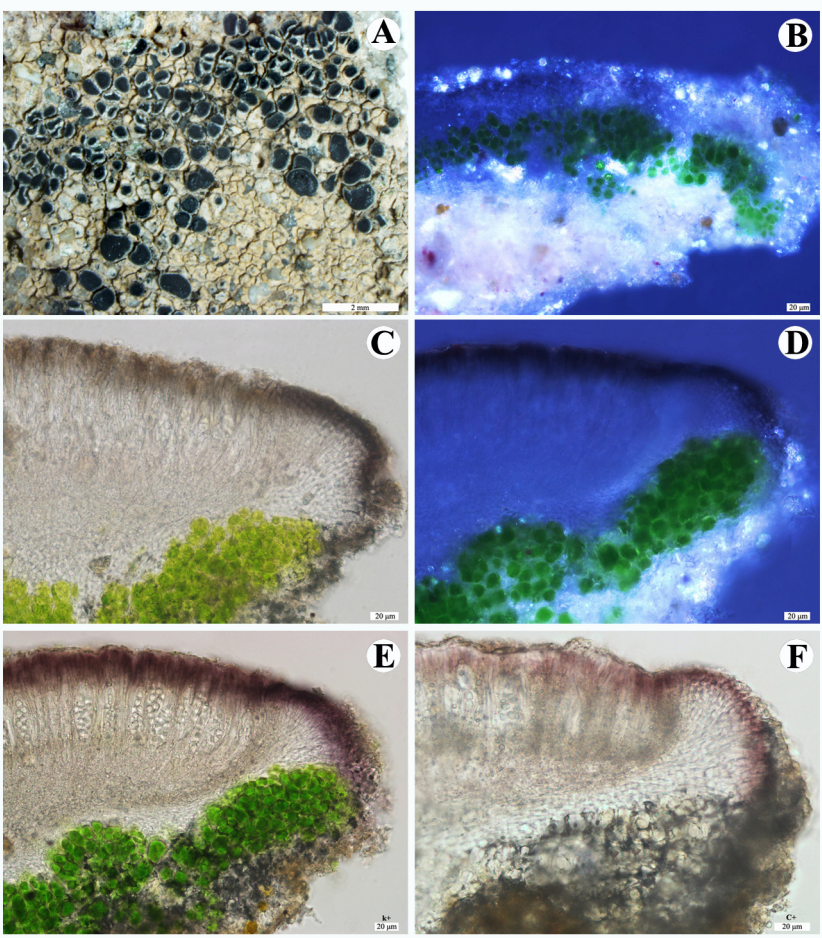

Figure 10. *Caloplaca diphyodes* (Wang 20122508, SDNU). A: Thallus; B: Even algal layer and crystals in cortex and medulla; C: Apothecium section; D: Crystals in amphithecium; E: K+ reaction in epihymenium, amphithecial cortex, and top of inner exciple; F: C+ reaction in epihymenium, amphithecial cortex, and top of inner exciple. Scale bars: A = 2 mm; B–F = 20 µm.

(SDNU), 20122664A (SDNU), 20123015A (SDNU), 20123253 (SDNU); 19 Aug. 2011, P.M. Wang 20123824A (SDNU); 19 Aug. 2011, X.R. Kou 20123879 (SDNU); 19 Aug. 2011, D.B. Tong 20122781A (SDNU).

Comments — *Caloplaca atroalba* and *C. ursina* resemble C. *diphyodes* in a nonstipitate areolate thallus and entirely raised black epruinose apothecia. However, *C. atroalba* has ascospores with a narrower isthmus (1.5–3 µm; Wetmore 1995), paraphyses with slightly swollen apical cells, and a weakly K+

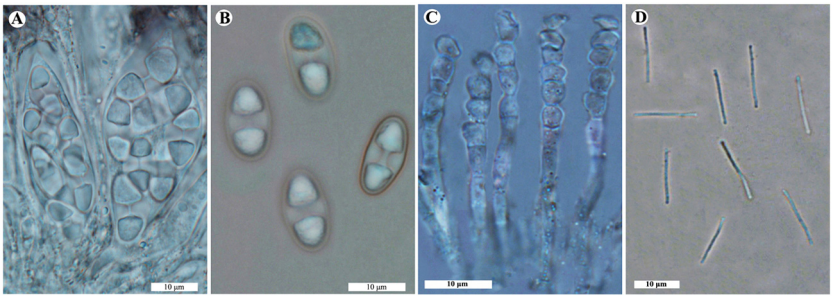

Figure 11. *Caloplaca diphyodes* (Wang 20122508, SDNU). A: 8-spored ascus; B: Polarilocular ascospores; C: Simple paraphyses with 3–6 swollen apical cells; D: Filiform conidia. Scale bars = 10 µm.

purple epihymenium while *C. ursina* has a K– epihymenium and amphithecial cortex.

Caloplaca pulicarioides Aptroot, Trop. Bryol. 17: 69 (1999) Fig. 12

Morphology — Thallus corticolous, crustose, white to greenish white, areolate; cortex with indistinct crystal; medulla with obvious crystals; algal layer even; prothallus not seen. Apothecia lecanorine, adnate to immersed; disc brown to red-brown, epruinose; top of inner exciple concolorous with disc; amphithecium with obvious crystals; epihymenium brown, without crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 7.5–10 × 4–5 µm, isthmus 1.5–2.5 µm; paraphyses simple to branched at the top, without swollen cells. Pycnidia present, numerous, ostiole brown to red-brown; conidia bacilliform, 2.5–3.5 × 0.8–1.2 µm.

Chemistry — Epihymenium, top of inner exciple, and amphithecium K–, C–. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: two unknown substances (S-1, S-2) detected by TLC.

Distribution — *Caloplaca pulicarioides* has been reported from Africa and Hong Kong, China (Aptroot & Seaward 1999, Seaward & Aptroot 2003). New to northern China.

Specimens examined: **China**. **Shandong**, Rongcheng county, Mt. Chengshan, alt. 50 m, on bark, 20 Jul. 2011, L. Li 20116198 (SDNU), 20127916 (SDNU), 20116529 (SDNU), 20116525A (SDNU), 20116544A (SDNU), 20116630A (SDNU); 20 Jul. 2011, H.Y. Wang 20116103A (SDNU), 20116537A (SDNU), 20116538B (SDNU), 20116534A (SDNU), 20116533 (SDNU), 20116532 (SDNU), 20116199 (SDNU), 20116535 (SDNU); Yantai city, Mt. Kunyu, alt. 300 m, on bark, 9 Jun. 2010, Y.L. Cheng 20127923 (SDNU).

Comments — *Caloplaca pulicarioides* superficially resembles species of the *Lecanora pulicaris*-group, but its polarilocular ascospores place it in *Caloplaca*.

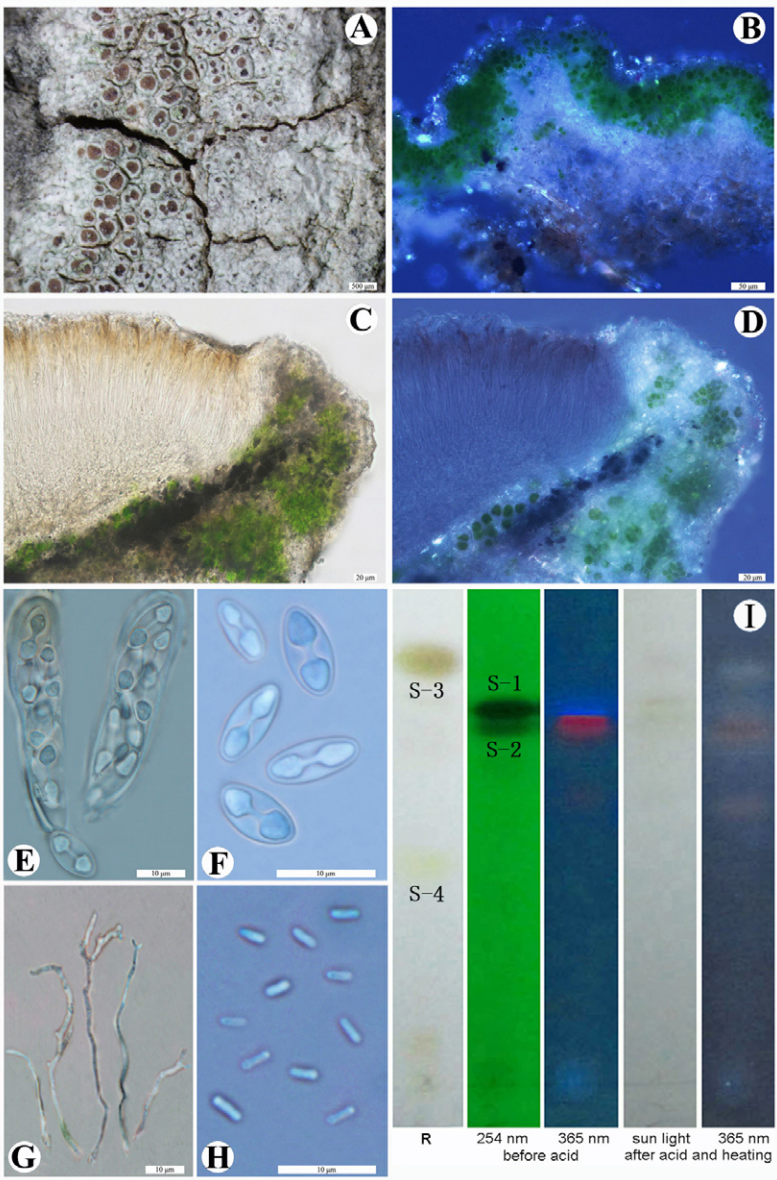

Figure 12. *Caloplaca pulicarioides* (Li 20116198, SDNU). A: Thallus; B: Even algal layer and crystals in cortex and medulla; C: Apothecium section; D: Crystals in amphithecium; E: 8-spored ascus; F: Polarilocular ascospores; G: Simple to branched paraphyses without swollen cells; H: Bacilliform conidia; I: TLC result (S-3 = Atranorin; S-4 = Norstictic acid). Scale bars: A = 500 μm; B = 50 μm; C, D = 20 μm; E–H = 10 μm.

The morphologically similar *C. homologa* and *C. trilocularis* differ in their consistently 3-loculate ascospores.

Caloplaca variabilis (Pers.) Müll. Arg., Mém. Soc. Phys. Hist. nat. Genève 16(2): 387 (1862) Figs 13, 14

Morphology — Thallus saxicolous, crustose, gray to blackish gray, partly stipitate areolate; cortex with crystals in some places; medulla with crystals; algal layer clustered; prothallus not seen. Apothecia lecanorine, sessile, round

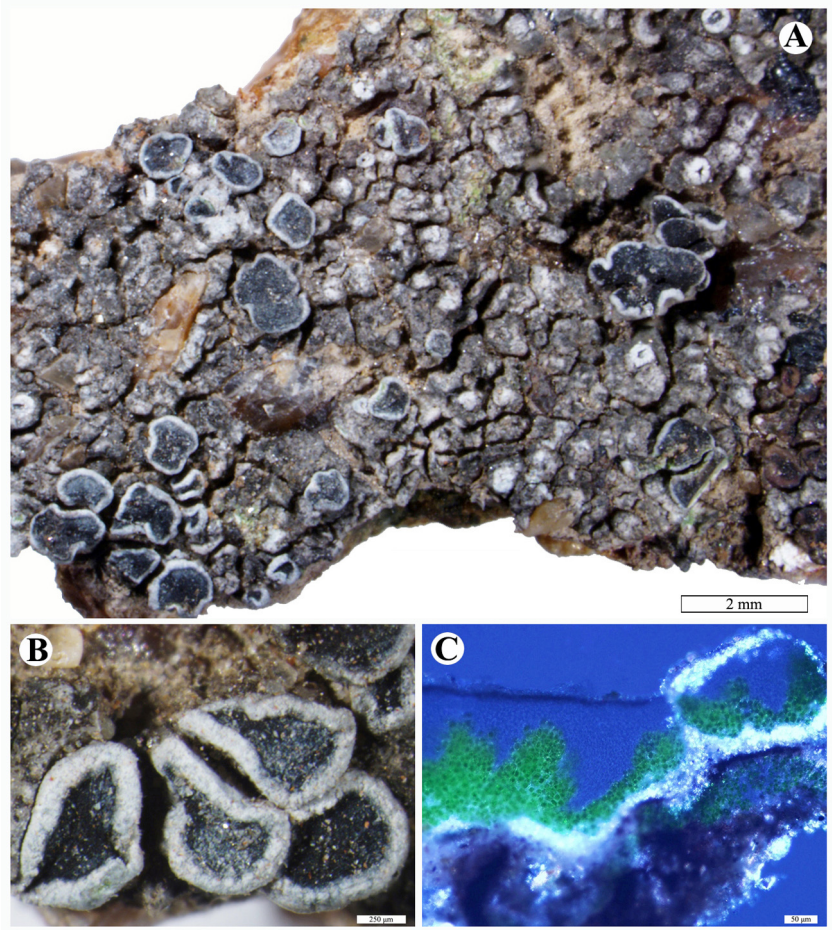

Figure 13. *Caloplaca variabilis* (Wang 20124114, SDNU). A: Thallus; B: Apothecial margin with thick pruina; C: Clustered algal layer and crystals in cortex and medulla. Scale bars: A = 2 mm; B = 250 µm; C = 50 µm.

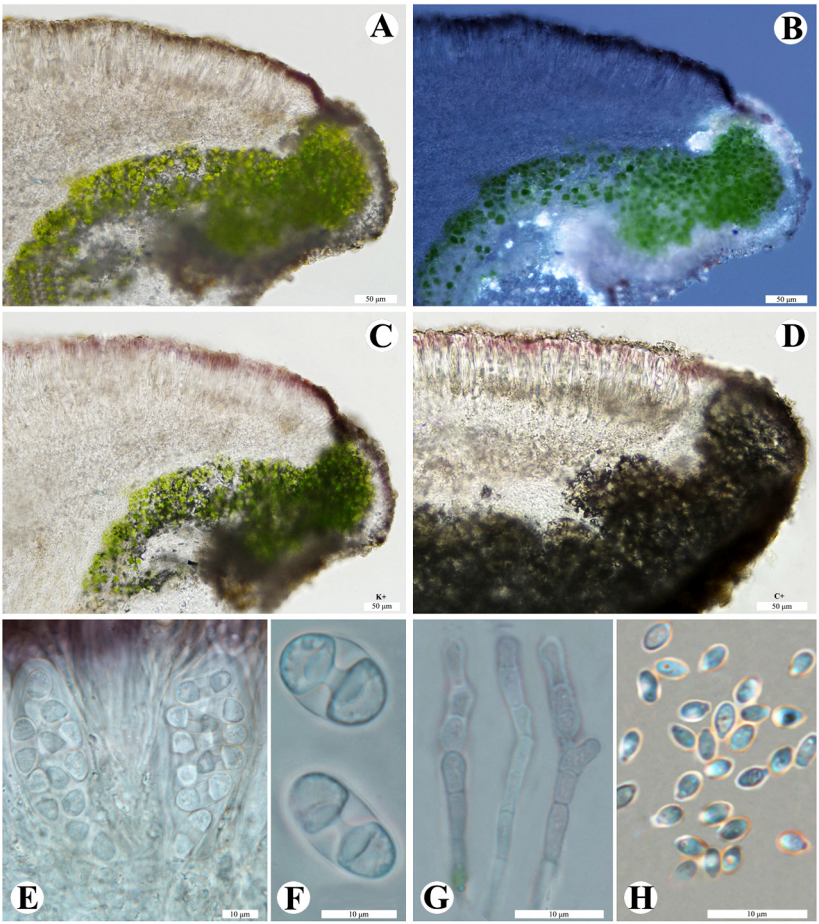

Figure 14. *Caloplaca variabilis* (Wang 20124114, SDNU). A: Apothecium section; B: Crystals in amphithecium; C: K+ reaction of epihymenium and top of inner exciple; D: C+ reaction of epihymenium and top of inner exciple; E: 8-spored ascus; F: Polarilocular ascospores; G: Simple to branched paraphyses with 2–4 somewhat swollen apical cells; H: Pyriform conidia. Scale bars: A–D = 50 µm; E–H = 10 µm.

to angular; disc black, sometimes pruinose; top of inner exciple concolorous with disc; amphithecium with thick pruina, thick algal layer, and crystals; epihymenium dark brown, without crystals; hymenium and subhymenium hyaline. Ascus 8-spored; ascospores polarilocular, ellipsoid, 15–20 × 7.5–10 µm, isthmus 2–3 µm; paraphyses simple to branched at the top, with 2–4 somewhat swollen apical cells. Pycnidia present, numerous, ostiole black; conidia pyriform, 3–4× 1.5–2 µm.

Chemistry — Epihymenium and top of inner exciple K+ weakly purple, C+ weakly purple; amphithecium K–, C–. Thallus and medulla K–, C–, KC–, P–. Secondary metabolites: no lichen substances detected by TLC.

Distribution — *Caloplaca variabilis* has been reported from Asia, Europe, and North America (Fryday 2004, Wetmore 1995, 2007, Yazıcı et al. 2008). New to China.

Specimen examined: **CHINA**. **Shanxi**, Ningwu county, Mt. Luya, alt. 2500 m, on rock, 26 Aug. 2011, H.Y. Wang 20124114 (SDNU).

Comments — *Caloplaca atroalba*, *C. diphyodes,* and *C. ursina* resemble *C. variabilis* but differ in their nonstipitate areolate thalli and non-pruinose apothecia. *Caloplaca atroalba* and *C. diphyodes* have even algal layers, and *C. atroalba* is further distinguished by ascospores with a poorly formed isthmus. *Caloplaca ursina* has a K– epihymenium and thallus cortex.

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